

FROGS AS INSECT COLLECTORS.*

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Since 1915, the writer has been accumulating data on the food of the common frogs of the Eastern United States; *Rana catesbeana* Shaw., *Rana clamitans* Latreille, *Rana sylvatica* Le Conte, *Rana palustris* Le Conte, *Rana pipiens* Schreber and *Hyla pickeringii* Holbrook. The frogs for this study were collected in Pennsylvania and New York state throughout the summer months from April until November. They were immediately placed in formaldehyde or alcohol to prevent further digestion of the contents of their stomachs. Many of the frogs examined by previous workers were not collected for food examination and much valuable material was lost because the digestion continued until the frogs were pickled upon return to the laboratory. The contents of the stomachs were examined by the wet method, that is under alcohol or formaldehyde as it was found that delicate structures such as the wings of insects or larval skins could not be adequately detected when dry. An attempt was made to collect one hundred specimens of each species a month in order that a thorough study of their food might be made. By conducting the work in this manner, the variety that occurs in the food diet throughout the season, the differences in the food diet of the various species, their feeding activities during the breeding season and their activities during the day time and the night time could be determined.

In the course of the study, it was soon realized that insects and Crustacea form the principal diet of frogs and that they are often unconsciously excellent collectors of certain rare insects. Several interesting and valuable records of the distribution of insects have been secured from specimens taken from the alimentary canals of frogs. They appear in many cases to be better collectors than some entomologists. Their proximity to the

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ground, alertness and ability to reach places where man finds it difficult, no doubt account for this.

The food of frogs, in general, consists of several groups of animals: Annulata (worms), Mollusca (snails), Crustacea (crayfishes), Arachnida (spiders, scorpions, mites, etc.), Hexapoda (insects), and Amphibia (frogs). The latter reveals their cannibalistic habits. Some writers, on the presence of a feather or mammal's hair, include the Aves and the Mammalia in the food list. The writer, after an examination of over five hundred frogs, is unable to add these as food, although bird feathers were found on two occasions within the stomachs of frogs. An extraordinary bit of diet was found in a bullfrog, now in the collection at Cornell University, which swallowed a young alligator; the tip of its tail was protruding from the frog's mouth at the time the specimen was observed. Such unique morsels of food are sometimes found, but they are unusual rather than the favorite diet of the frogs. There is no doubt, that amid the great variety of food, insects form their principal diet. This is true, unless it be one species, *Rana catesbeana*, which has been more often found filled with Crustacea and Arachnida.

The problem of the food of frogs resolves itself, in a large degree, to a study of their insect diet and it is natural therefore that an abundance of interesting notes have been secured on insect distribution. In identifying the food contents of frogs, the orders, families, genera and in many cases the species have been determined. The identification of the species has been left to specialists. The work was conducted at Ithaca, N. Y., where the following specialists were available: Dr. O. A. Johannsen (Diptera), Dr. Wm. T. Forbes (Lepidoptera), Prof. C. R. Crosby (Arachnida), Dr. J. C. Bradley (Hymenoptera), Mr. Henry Dietrich (Coleoptera adults). Mr. Adam Boöving of Washington, D. C., was kind enough to determine the Coleoptera, larvæ. The efforts and co-operation of these systematists have greatly enhanced the value of the work. Much of the material is still undetermined including the Lepidoptera and the Hymenoptera, however considerable data have been accumulated on the Diptera, Coleoptera and Arachnida, which add greatly to our knowledge on this subject.

The determination of the contents of the alimentary canal is not a difficult task but is often tedious work. Upon the first examination of the contents of a stomach, nothing but a mass of material can be distinguished. This must be carefully picked apart before any material can be determined or even before insects or other forms can be recognized. Earth worms crowd the alimentary canal with considerable earth, moths, with scales, caterpillars, with hair, and in addition to these, one finds gravel, stones, leaves, seeds and other foreign material. Within the intestine the food is found in a more moist condition, and there is usually very little material at any time. The colon is often jammed with a quantity of material much of which is considerably digested and frequently beyond recognition. The elytra of beetles, heads and legs of many insects often remain to tell the story while the wings of insects may be badly twisted and torn, but still they can be unfolded and the family, genus and sometimes the species determined.

An extraordinary wide variety of insects has been secured from the contents of the alimentary canals of frogs. Representatives of fifteen of the nineteen order of insects recognized by Prof. J. H. Comstock have been taken and numerous families and genera are represented. The two parasitic orders Siphonaptera and Mallophaga would probably never be found unless taken upon their hosts. There is no reason to doubt that the other two orders might be eaten by frogs should they come in their path. Sometimes only a single specimen of a species was found, while at other times a large number of specimens was taken. Ants and beetles, especially the Carabidæ and the Curculionidæ, form a large part of their diet. In one case 53 ants were found in a single stomach of a bullfrog, while in another, 114 were found. The beetles are mostly large and dark colored and form attractive food for the frogs. Twelve Curculionidæ (*Phyxelis rigidus* Say), were taken from a single stomach. Flies (Diptera) likewise were found, at times, in large numbers. In opening the stomach of a green frog, the writer found fifteen specimens of *Eristalis arbustorum* (Syrphidæ). Other insects, as the Collembola, aphids, psocids and such as naturally occur in colonies, were often found in large numbers. Two groups of Arthropods, the Hexapoda and Arachnida, have thus far been found exceedingly interesting and in such

good condition that a large number of species has been determined. The larvæ of the Stratiomyidæ (Diptera) and the Arachnida (spiders) have yielded new distribution records for the fauna of New York State.

The adults of the Stratiomyidæ have not been found abundant but the larvæ have attracted much attention. These have been taken from the green, bull and meadow frogs. They are among the most beautiful of the dipterous larvæ and are readily recognized amidst the trash of the stomach contents. Five genera have been taken from frogs; *Stratiomyia*, *Odontomyia*, *Nemotelus*, *Allognosta* and *Oxycera*. The larvæ of the first five genera are known to be aquatic in their habits. *Odontomyia* adds a new larva of a local species to the collection at Cornell University. That of *Nemotelus* lends the first larval record of a North American species. Such a variety of stratiomyid larvæ is more than a dipterist has in his own collection. These larvæ were found in a beautiful condition. The weak acids of the frog's stomach remove the fatty material from the larvæ and render them in as fine a condition as specimens treated with weak potassium hydroxide at the laboratory. The skins are thereby made transparent and reveal the setæ and head structures clearly. The skins of such larvæ can be very easily determined.

Spiders were likewise found in abundance and many times in excellent states of preservation. Often it was necessary to do much cleaning before the spider was even visible because the legs would frequently curl up and entangle large masses of digested food. The male palpi, a valuable character in taxonomic work, are made more distinct and are often extended to their full length by the action of the digestive fluids of the frog. Such specimens are frequently more tempting to the systematists than poorly collected or preserved material. Spiders were found in greatest abundance in the pickerel, meadow, green and wood frogs. Fourteen species have been determined; *Pirata insularis* Em., *Pardosa moesta* Beck and *Clubiona abbotii* Koch were taken most frequently. *Schizocosa crassipalpis* Em., adds a new record to the list of spiders of New York State. Three specimens of this species were taken; two from a meadow frog and one from a pickerel frog.

As one studies the food of frogs, one realizes more and more that the food is gathered from insects dwelling on or near the ground or near the surface of the water. The Carabidæ, living near the ground, the snout beetles (Curculionidæ), dropping to the ground when disturbed, the Syrphidæ hovering over ponds, the water striders and beetles living on the surface of the water; all of these make inviting and easily obtainable food. The amount of food taken from the water, as aquatic larva, is considerable and greater than has been hitherto stated. In addition to the food and trash found in frogs, large numbers of parasites have been found. These cannot be properly considered as food but their presence is worth mentioning. *Hyla pickeringii* yielded large numbers of nematodes. Flukes also were found in some frogs.

The records thus far secured, have been a great incentive to continue the work, not alone for the valuable contribution it may be to a study of the food of frogs, but also for the possibility of adding new records and new species to our fauna. This study has opened a new field for exploitation and a new source for records of insects' distribution.

LARVAE OF INSECTS RECOVERED FROM THE ALIMENTARY CANALS OF FROGS.*

Order, Family, Species.	Number of specimens recovered.
LEPIDOPTERA	
Satyridæ	
<i>Satyrodes acanthus</i> Linn.	2
Geometridæ	
<i>Xanthrohoe</i> sp.	1
Lasiocampidæ	
<i>Malacosoma disstria</i> Hubn.	1
Gelechiidæ	
Undetermined species	1
Noctuidæ	
<i>Nephelodes emmedonia</i> Cram.	1
<i>Catocala</i> species	1

*Many of the Lepidoptera and all of the Hymenoptera are still undetermined.

Order, Family, Species.	Number of specimens recovered.
<i>Leucania</i> species	1
<i>Noctua</i> species	1
COLEOPTERA	
Carabidæ	
<i>Pterostichus</i> species	3
<i>Chlaenius</i> species	4
Dytiscidæ	
<i>Agabus</i> species	1
Hydrophilidæ	
<i>Hydrobius globosus</i> Say	1
<i>Tropisternus</i> species	1
Silphidæ	
<i>Silpha</i> species	1
Staphylinidæ	
<i>Quedius</i> species	1
Histeridæ	
Undetermined species	1
Lampyridæ	
<i>Photinus</i> species	1
<i>Telephorus</i> species	9
Chrysomelidæ	
<i>Leptinotarsis</i> species	1
DIPTERA	
Mycetophilidæ	
<i>Sciara</i> species	4
Tipulidæ	
<i>Tipula bella</i>	1
Muscidæ	
Undetermined species	1
Stratiomyiidæ	
<i>Oxycera picta</i> V. d. W.	1
<i>Stratiomyia</i> species	3
<i>Nemotelus</i> species	1
<i>Odontomyia</i> species	1
<i>Allognosta</i> species	1
NEUROPTERA	
Chrysopidæ	
<i>Chrysops</i> species	1

ADULT INSECTS RECOVERED FROM THE ALIMENTARY
CANALS OF FROGS.†

Order, Family, Species.	Number of specimens recovered.
THYSANURA undetermined	
EPHEMERIDAE undetermined	
ODONATA undetermined	
PLECOPTERA undetermined	
CORRODENTIA undetermined	
ORTHOPTERA	
Blattidæ	
<i>Parcoblatta pennsylvanica</i> De. Geer.....	1
PHYSOPODA	
Undetermined	
HEMIPTERA	
Jassidæ	
<i>Helochara communis</i> Say	6
<i>Draeculacephala aquilifera</i> Walk.....	1
Tingitidæ	
<i>Corythucha juglandis</i> Say	2
Hydrobatidæ	
<i>Gerris remigis</i> Say	2
<i>Gerris marginata</i> Say.....	4
Reduviidæ	
<i>Reduviolus fesus</i> L	1
Pentatomidæ	
<i>Euschistus custignus</i> Say	1
<i>Euschistus fissilis</i> Uhl.	1
Saldidæ	
<i>Lampracanthia anthracina</i> Uhler	1
Corimelaenidæ	
<i>Thyrecoris unicolor</i> P. B.	6
NEUROPTERA	
Sialidæ	
<i>Chauliodes sericornis</i> Say	1
Chrysopidæ	
<i>Chrysops</i> species	2
MECOPTERA	
Panorpidæ	
<i>Panorpa</i> species	1

† This list contains only material determined to genus or species. The insects of many of the orders are still undetermined.

TRICHOPTERA

Undetermined

LEPIDOPTERA

Undetermined

DIPTERA

Chironomidæ

Chironomus decorus 1

Mycetophilidæ

Sciara species 2

Tipulidæ

Tipula bella Loew 1*Tipula dietziana* Alex. 1*Tipula* near *tephrocephala* Loew. 1*Erioptera graphica* O. S. 1*Erioptera armata* O. S. 2*Gonomyia subcinerea* O. S. 2*Gonomyia sulphurella* O. S. 1*Pilaria tenuipes* Say. 1*Ptychoptera rufocincta* O. S. 1

Trypetidæ

Urellia species 1*Eutreta* species 2

Platypezidæ

Platypeza species 1

Syrphidæ

Eristalis arbustorum 15

COLEOPTERA

Cicindelidæ

Cicindela sexguttata Fab. 1

Carabidæ

Bembidium nigrum Say. 1*Bembidium flavopictum* Mots. 1*Pterostichus* species 1*Poecilus lucublandus* Say 18*Amara insensu* L. & H. 1*Platynus melanarius* Dej. 3*Platynus tenuis* Lec. 2*Platynus excavatus* Dej. 1*Lebia* species 1*Chlaenius* species 1*Harpalus dichrous* Dej. 1*Stenolphus fuliginosus* Dej. 1*Stenolphus riparius* L. 1*Anisodactylus* species 3*Micromaseus patruelis* (Dej.) 1

<i>Pseudargutor erythropus</i> (Dej.)	1
<i>Triaena angustata</i> (Say.)	6
<i>Triliarthrus kirbyi</i> (Horn)	1
Dytiscidæ	
<i>Agabus semivittatus</i> Lec.	1
Hydrophilidæ	
<i>Helophorus</i> species	1
<i>Creniphilus</i> species	1
Bøstrichidæ	
Undetermined	1
Cupesidæ	
<i>Cupes concolor</i> Westw.	1
Scarabaeidæ	
<i>Aphodius finetarius</i> Linn.	1
<i>Ataenius cognatus</i> (Lec.)	1
Chrysomelidæ	
<i>Donacia rufra</i> Say	6
<i>Calligrapha similis</i> Rogers	1
<i>Calligrapha philadelphica</i> Linn.	1
<i>Calligrapha elegens</i> Oliv	2
<i>Calligrapha bisbyana</i> Kirby	4
<i>Iina ininterrupta</i> Fab.	1
<i>Iina lapponica</i> (L)	1
<i>Cerotoma trifurcata</i> Forst	6
<i>Prasocuris vittata</i> Oliv.	2
<i>Leptinotarsa decimlineata</i> Say	1
<i>Galerucella nymphacae</i> L.	8
<i>Diabrotica 12 punctata</i> Fabr.	1
<i>Oedionychis vians</i> Illig.	1
<i>Disonycha pennsylvanica</i> Illig.	1
<i>Disonycha xanthomelaena</i> Dalm.	2
<i>Mantura floridana</i> Crotch	1
<i>Systema taeniata</i> Say	1
<i>Anthoboscus ruricola</i> (Oliv.)	1
Anthicidæ	
Undetermined species	15
Staphylinidæ	
<i>Staphylinus mysticus</i> Erichs.	1
<i>Philinothus</i> species	4
<i>Stenus</i> species	4
<i>Lathrobium</i> species	1
<i>Palaminus testaceus</i> Erichs.	1
<i>Gastrolobium bicolor</i> (Grav.)	1

Coccinellidæ

<i>Hippodamia parenthesis</i> Say	1
<i>Hippodamia 13 punctata</i> Linn.	2
<i>Coccinella transversoguttata</i> Fald.	1
<i>Adalia bipunctata</i> (L)	1
<i>Hyperaspis undulata</i> (Say)	2
<i>Chilocorus bivulnerus</i> Muls.	1
<i>Ceratomegilla maculata</i> De Geer	4
<i>Ceratomegilla fuscilabris</i> (Muls)	1

Erotylidæ

<i>Languria mozardi</i> Latr.	1
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Cryptophagidæ

<i>Ceratophagus abbreviatus</i> Say	9
<i>Tomarus pulchellus</i> Lec.	3
<i>Atomaria</i> species	1
<i>Anchicera ephippiata</i> Zimm.	1

Dermestidæ

<i>Dermestes lardarius</i> Linn.	1
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Nitidulidæ

<i>Epuraea helvola</i> Erichs	1
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Lathridiidæ

<i>Corticaria</i> species	1
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Heteroceridæ

<i>Heterocerus</i> species	5
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Byrrhidæ

<i>Limnichus punctatus</i> Lec.	1
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Dascyllidæ

An undetermined species	1
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Elateridæ

<i>Melanotus</i> species	1
<i>Agriotes mancus</i> (Say)	15
<i>Ludius tarsalis</i> (Melsh)	3
<i>Monocrepidius auritus</i> (Hbst.)	2
<i>Dolopius lateralis</i> Esch.	1

Dryopidæ

<i>Helicus lithophilus</i> (Germ.)	1
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Lampyridæ

<i>Photinus</i> species	1
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Curculionidæ

<i>Phyrelis rigidus</i> Say.	12
<i>Homorus undulatus</i> (Uhler)	1
<i>Brachyrhinus rugifrons</i> Gyll	11
<i>Brachyrhinus ovatus</i> Linn.	11
<i>Sitonia hispidula</i> Fab.	4
<i>Phytonomus nigrirostris</i> Fab.	1

<i>Hyperodes porcellus</i> Say	7
<i>Notaris puncticollis</i> (Lec.)	2
<i>Onychylis nigerostris</i> Boh.	1
<i>Anthonomus</i> species	1
<i>Ceutorhynchus marginatus</i> Payk.	2
<i>Conotrachelus anaglypticus</i> Say.	1
<i>Cryptorhynchus lapathi</i> Linn.	1
<i>Hypera punctata</i> (Fab.)	6

ARACHNIDA RECOVERED FROM THE ALIMENTARY CANALS
OF FROGS.

Family, Species.	Number of specimens recovered.
Clubionidæ	
<i>Clubiona</i> species	2
<i>Clubiona abbotii</i> Koch.	3
<i>Clubiona mixta</i> Em.	1
Lycosidæ	
<i>Lycosa</i> species	3
<i>Lycosa erratica</i> Hlz.	1
<i>Pirata insularis</i> Em.	3
<i>Pirata febriculosus</i> Beck	1
<i>Pardosa moesta</i> Banks.	4
<i>Pardosa milvina</i> Hlz.	1
<i>Schizocosa crassipalpis</i> Em.	1
Thomisidæ	
<i>Oxyptila censpurgata</i>	3
<i>Xysticus ferox</i> Hlz.	6
Mimetidæ	
<i>Ero furcata</i> Vill.	1
Linyphiidæ	
<i>Erigone</i> species	3
<i>Linyphia calthrata</i>	2
Agelenidæ	
<i>Agelena naevia</i>	1
Attidæ	
<i>Stitticus palustris</i> Peck.	1
Cheliferidæ	
An undetermined species	1

